/CDF/ANAL/EXOTIC/CDFR/….

Searches for First Generation Leptoquarks in the eejj channel

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Abstract

We report on a search for first generation scalar leptoquarks, S1, done using 80 pb^{-1} of run II data. Leptoquarks are assumed to be pair produced and to decay into lepton and quark . The signature for this channel is two energetic electrons and 2 jets. We set an upper limit at 95% CL on the production cross section as a function of the mass of the leptoquark and by comparison with the theoretical calculations of the cross section. We set a lower limit on the M_{S1} for β=1 (β = Br(LQ$\rightarrow$eq)).

Introduction

Leptoquarks are hypothetical color-triplet particles carrying both baryon and lepton quantum numbers and are predicted by many extension of the Standard Model as new bosons coupling to a lepton-quark pair[1]. Their masses are not predicted. They can be scalar particles (spin 0) or vector (spin 1) and at high energy hadron colliders they would be produced directly in pairs, mainly through gluon fusion or quark antiquarks annihilation. In figure 1 a typical production diagram is reported.

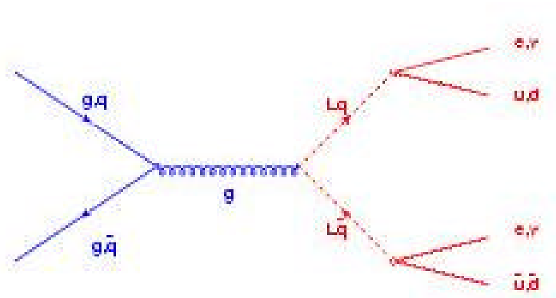


Figure 1

The couplings of the leptoquarks to the gauge sector are predicted due to the gauge symmetries, up to eventual anomalous coupling in the case of vector leptoquarks, whereas the fermionic couplings λ are free parameters of the models. In most models leptoquarks are expected to couple only to fermions of the same generations because of experimental constraints as non observation of flavor changing neutral currents or helicity suppressed decays. The production cross section for pair produced scalar LQ has been calculated up to NLO[2].The decay angular distribution of scalar leptoquarks is isotropical. The NLO cross section at $\sqrt{s}$ = 1960 GeV is reported in Table 0 for values of the LQ mass between 200 and 320 GeV/c^2 . The scale has been chosen to be $Q^2 = M_{LQ}^2$ and the set of pdf is CTEQ4M[].

M_{LQ} (GeV/c^2)	σ(NLO) [pb]
200	0.265E+00
220	0.139E+00
240	0.749E-01
260	0.412E-01
280	0.229E-01
300	0.129E-01
320	0.727E-02

Table 0

This analysis is focused on the search for first generation scalar leptoquarks S1, pair produced and decaying into eejj. The analysis strategy is a repetition of the run I analysis[3] and at this moment improvements and optimization of cuts are not performed.

Current Limits

In table 1 the current limits on the first generation LQ are reported, both from CDF and D0.

1st Gen	β	Scalar (GeV/c^2)	Vector – minimal coupling (GeV/c^2)	Vector – Yang-Mills coupling (GeV/c^2)
DZero	1 0.5 0	225(242) 204 98	292 282 238	345 337 298
CDF	1 0.5	220 (242) 202	280 265	330 310

Table 1

Data sample and electron identification

The data sample used for this analysis is *btop0g* (inclusive electrons) stripped for the Top group from the inclusive high pt electron datasets. The sample is described in[4].
The L3 trigger dataset *(bhel08*) was reconstructed with offline version 4.8.4 and the events were filtered into *btop0g* using the following loose cuts:

- CdfEmObject.Pt > 9.0 GeV
- CdfEmObject.etCalMin > 18.0 GeV
- CdfEmObject.delX < 3.0
- CdfEmObject.delZMin < 5.0
- CdfEmObject.E/P < 4.0
- CdfEmObject.lshr < 0.3
- CdfEmObject.hademMax < 0.125

For the ELE_70 trigger :

- CdfEmObject.Pt > 15.0 GeV
- CdfEmObject.etCalMin > 70.0 GeV
- CdfEmObject.delX < 3.0
- CdfEmObject.delZMin < 5.0

A REMAKE version of *b0topg* was made where all the calorimeter-dependent objects were dropped in input as well as electron and muon reconstruction objects. The 4.8.4 tracks were refitted (using TrackRefitModule) without L00 hits, and electron and muon objects were remade picking up the refit tracks and run-dependent calorimeter corrections. The sample is on fcdfsgi2 in
/cdf/data54/ewk/data/highpt_491/Inclusive-ele_484_REMAKE
and corresponds to an integrated luminosity of 51.2 pb^{-1} (good runs between March 23 – December 1, 2002 – runs 141544 to 154799).

The sample has been reduced by requiring 2 CdfEmObjects (trackid != 0) with $E_T > 25$ GeV and calorimeter isolation < 0.15 on both legs. It consists of …. Events.
We then require a central electron to satisfy stringent cuts, with a second one in the central or plug region passing looser cuts, in order to maintain good efficiency.
The electron are identified by the standard cuts used in the Z' analysis and the efficiencies are reported in Table 2 and 3.

The electron selection cuts are listed below:

Central electron (loose or tight)

- $E_t \geq 25$ GeV

- p_t > 13 GeV
- hadem <= 0.055 + 0.00045 * E
- E/p < 4 (for Pt < 50 GeV)
- iso4e/emet < 0.1 (0.2 for second central loose)
- |DeltaX | < 3.0 cm
- | DeltaZ | < 5.0 cm
- lshr <= 0.2
- Fiducial = 1

Second plug electron

- Isolation < 0.1
- Had/em <= 0.055 + 0.00045 * E
- Fiducial 1<|η| < 3

Cut	Events	Background	Efficiency (%)
$Iso < 0.1$	1265	42	96.1 ± 0.4
$Iso < 0.2$	1357	72	98.6 ± 0.2
$E_{had}/E_{em} < 0.055 + 0.00045 \times E$	1415	130	98.6 ± 0.2
$E/P < 4.0$ (for $P_T < 50$)	1591	276	99.8 ± 0.1
$\lvert\Delta X\rvert < 3.0$	1529	252	98.3 ± 0.2
$\lvert\Delta Z\rvert < 5.0$	1579	272	99.5 ± 0.1
Tight central overall(ε_T)	1139	24	91.6 ± 0.6
Loose central overall(ε_L)	1201	36	93.7 ± 0.5
$\varepsilon_{CC} (= \varepsilon_T \cdot \varepsilon_L - \varepsilon_T^2)$			87.7 ± 0.9

Table 2

Cut	Events	Efficiency (%)
$Iso < 0.1$	1573	92.6 ± 0.6
$E_{had}/E_{em} < 0.055 + 0.00045 \times E$	1651	97.2 ± 0.4
Plug overall (ε_P)	1565	92.1 ± 0.7
$\varepsilon_{CP} (= \varepsilon_T \cdot \varepsilon_P)$		84.4 ± 0.8

Table 3

Acceptance calculation

We generated 5000 events samples of scalar leptoquarks pair decaying into *eq* for M_{LQ} in the range 200 to 320 GeV/c^2 using Pythia[]. The samples have been generated to simulate realistic beam conditions, emulating run number 151435 and using the following talk-to for the full beam position:

```
talk GenPrimVert
  BeamlineFromDB set false
  sigma_x        set  0.0025
  sigma_y        set  0.0025
  sigma_z        set 28.0
  pv_central_x   set -0.064
  pv_central_y   set  0.310
  pv_central_z   set  2.5
  pv_slope_dxdz  set -0.00021
  pv_slope_dydz  set  0.00031
exit
```

The samples were generated with $Q^2 = M_{LQ}^2$ and the MRS-R2 pdf set[]. The samples were simulated with cdfSim version 4.9.1 and Production 4.9.1 was ran on them.

The analysis cuts are the same as in run I:

- 2 ele with $E_T > 25$ GeV
- 2 jets with $E_T(j1) > 30$ and $E_T(j1) > 15$ GeV
- removal of events with $76 < M_{ee} < 110$
- $E_T(j1) + E_T(j2) > 70$ && $E_T(e1) + E_T(e2) > 70$
- $\sqrt{((E_T(j1) + E_T(j2))^2 + (E_T(e1) + E_T(e2))^2)} > 200$

The last cut was shown in run I to discriminate between signal and background, as shown in Figure 3. In Figures 4,5,6 the sum of the electrons E_T is plotted against the sum of the 2 jets E_T for signal, DY + 2 jets and tt after selecting 2 electrons and 2 jets. In Figure 7 the distribution for signal after all cuts is shown.

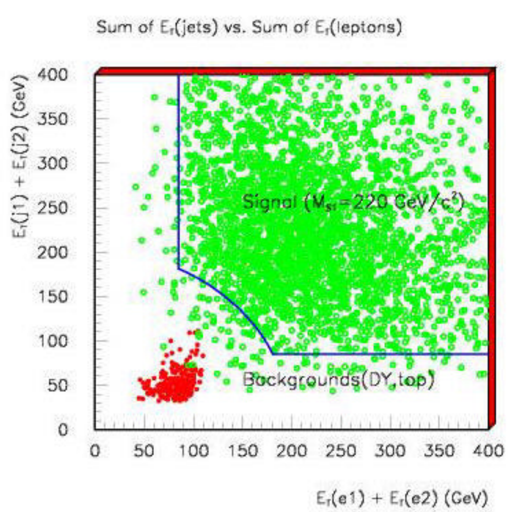
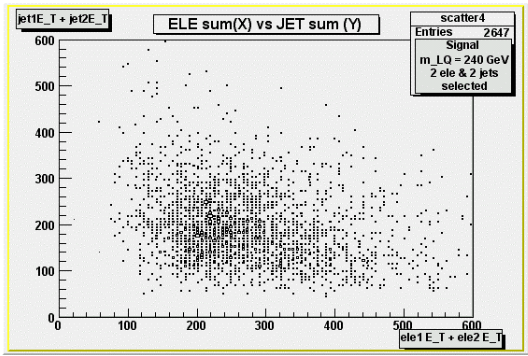


Figure 3



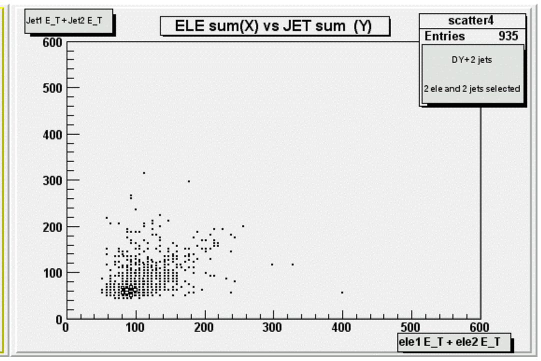
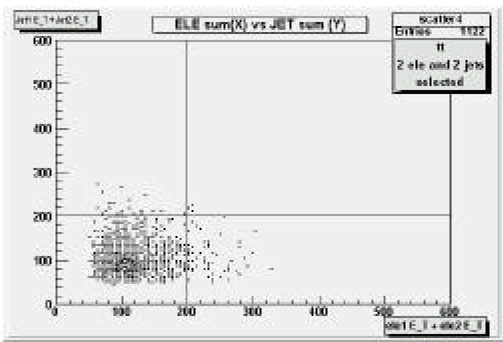


Figure 4

Figure 5



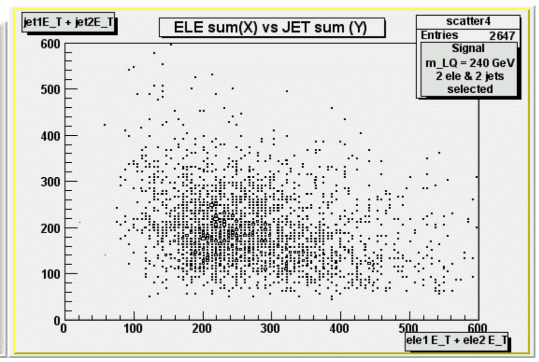


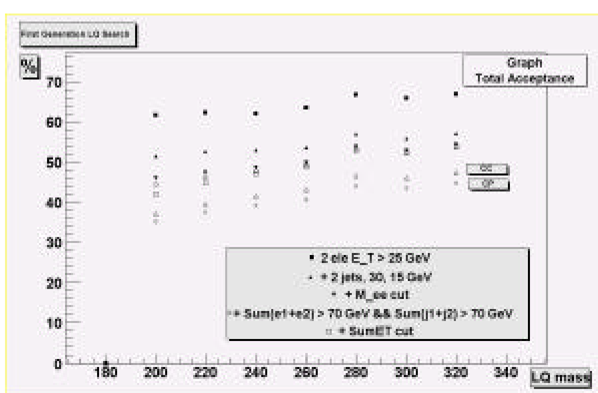
Figure 6

Figure 7

The analysis cuts efficiencies are calculated relatively to the number of events having 2 cdfEmObjects with track id different from 0 (to exclude photons), matching the generator level electrons in a cone in $\Delta R = \sqrt{(\Delta\eta+\Delta\varphi)^2} = 0.3$. They are reported in Table 1.

The efficiencies are then folded with the electron ID efficiencies calculated by [].

Trigger efficiencies is assumed 100% for ELE_70 and ELE_18 and was calculated by the time of the ICEHP conference.



M_{LQ} (GeV/c^2)	200	220	240	260	280	300	320
2 ele with E_T > 25 GeV	0.873±0.006	0.888±0.005	0.905±0.005	0.911±0.005	0.925±0.004	0.924±0.004	0.932 ±0.004
2 jets with E_T > 30, 15 GeV	0.723±0.008	0.740±0.007	0.768±0.008	0.763±0.007	0.785±0.007	0.777±0.007	0.790± 0.006
M_{ee} removal cut	0.625±0.009	0.644±0.008	0.685±0.008	0.690±0.008	0.712±0.008	0.711±0.008	0.731± 0.008
$\Sigma(E_T(ele_i))$ > 70 GeV & $\Sigma(E_T(jet_i))$ > 70 GeV	0.604±0.009	0.639±0.008	0.674±0.009	0.684±0.008	0.712±0.008	0.706±0.008	0.729± 0.008
$\Sigma(E_T(ele_i)+E_T(jet_i))$ > 200	0.574±0.009	0.612±0.008	0.664±0.009	0.679±0.008	0.709±0.008	0.703±0.008	0.727± 0.008

Table 4

The expected number of events of signal, given the above efficiencies is reported in table 4

Backgrounds

The main backgrounds is due to $\gamma/Z \rightarrow ee$ events accompanied by jets due to radiation. The main component of this background is eliminated by cuts on M_{ee} around the mass of the Z boson and the ΣE_T cuts. However there are still events from the DY continuum and Z events that fail the cuts due to mis-measurement. We studied the distribution of this background by generating the process Z + 2 jets with Alpgen[] and using the MC parton generator mcfm to obtain the NLO cross section.
The expcted number of events in 80 pb^{-1} is…..

Another source of background is represented by tt production where both the W decay into $e\nu$. Assuming a cross section for this process $\sigma(tt)\times Br(W\rightarrow e\nu)$ = 0.0739 pb, we expect 0.1 events….

Other backgrounds from bb, $Z\rightarrow\tau\tau$, WW are expected to be negligible due to the electron isolation and large electron and jet transverse energy requirements.
The number of expected events after the kinematical cuts are listed in the table below.

Systematics

Cross section Limit

Conclusions

Aknowledgements